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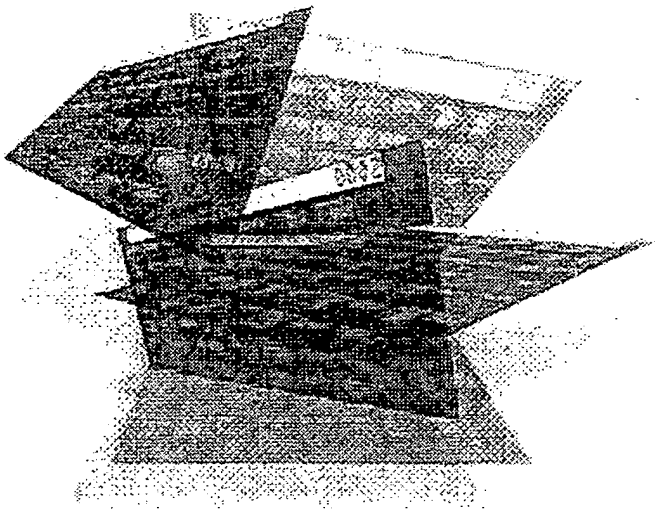

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AIR WEATHER SERVICE
MODEL OUTPUT STATISTICS SYSTEM
PROJECT REPORT

By

LT COL DONALD L. BEST
MAJ STEPHEN P. PRYOR

OCTOBER 1983

UNITED STATES AIR FORCE
AIR WEATHER SERVICE (MAC)
AIR FORCE GLOBAL WEATHER CENTRAL
OFFUTT AFB NE 68113

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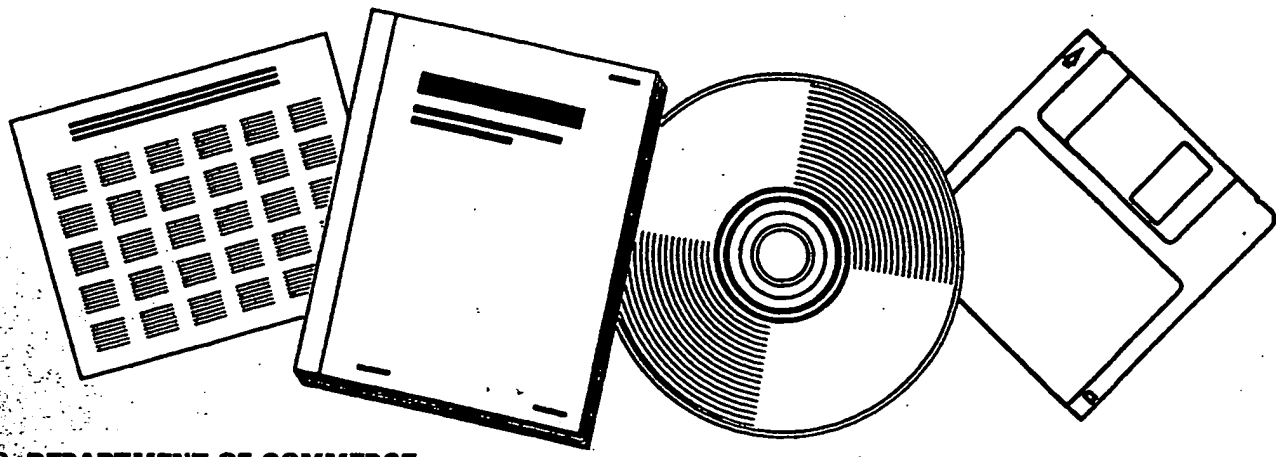
AIR WEATHER SERVICE MODEL OUTPUT STATISTICS SYSTEMS

AIR FORCE GLOBAL WEATHER CENTRAL
OFFUTT AFB, NE

OCT 1983



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Reinsurers Seek Relief in

BY RUSS BANHAM

P.D. 08-1993
p. 14-16 + 18-19 = 5

Companies specializing in computerized risk assessment of hurricanes, tornadoes and earthquakes are helping property reinsurers better manage their catastrophe exposures. The companies provide software that can be licensed by insurers, reinsurers and risk managers to allow them to more accurately predict the odds of a natural disaster striking and its consequent financial toll. Such disasters cost the industry more than $22 billion last year, $15.5 billion of which was generated by just two hurricanes.

The huge insured losses from the recent catastrophes forced the demise of many reinsurance companies, especially in London, which lost at least one-half of its property reinsurance capacity in the last two years. Those reinsurers that are still providing coverage have become more conservative, evidenced by their higher risk attachment levels, stricter underwriting and increased pricing.

Computerized weather prediction is part of this new trend toward more prudent underwriting. The technology not only provides scientific estimates of probable catastrophes before they occur, but also helps a reinsurer calculate its cedents' exposures, examine the geographic spread of its own and its cedents' risks, and estimate its potential property portfolio losses.

Since reinsurers generally pick up the catastrophic share of property policies, the emphasis on risk management makes clear sense. It's driven by the recent losses, and by studies projecting even higher losses from future storms – $53 billion for a Class 5 hurricane (155 mph and higher sustained winds with an 18 ft. and higher storm surge) striking Miami, or $51 billion for a Class 4 (131 to 155 mph sustained winds with a 13 to 18 foot storm surge) storm striking New Jersey and Long Island, according to the Natural Disaster Coalition in Washington, D.C.

The three companies making up the market for computerized catastrophe loss management are Risk Management Software Inc. in Mountain View, California; EQE International in San Francisco; and Boston-based Applied Insurance Research Inc. While they essentially provide similar services, each goes about it in a different way.

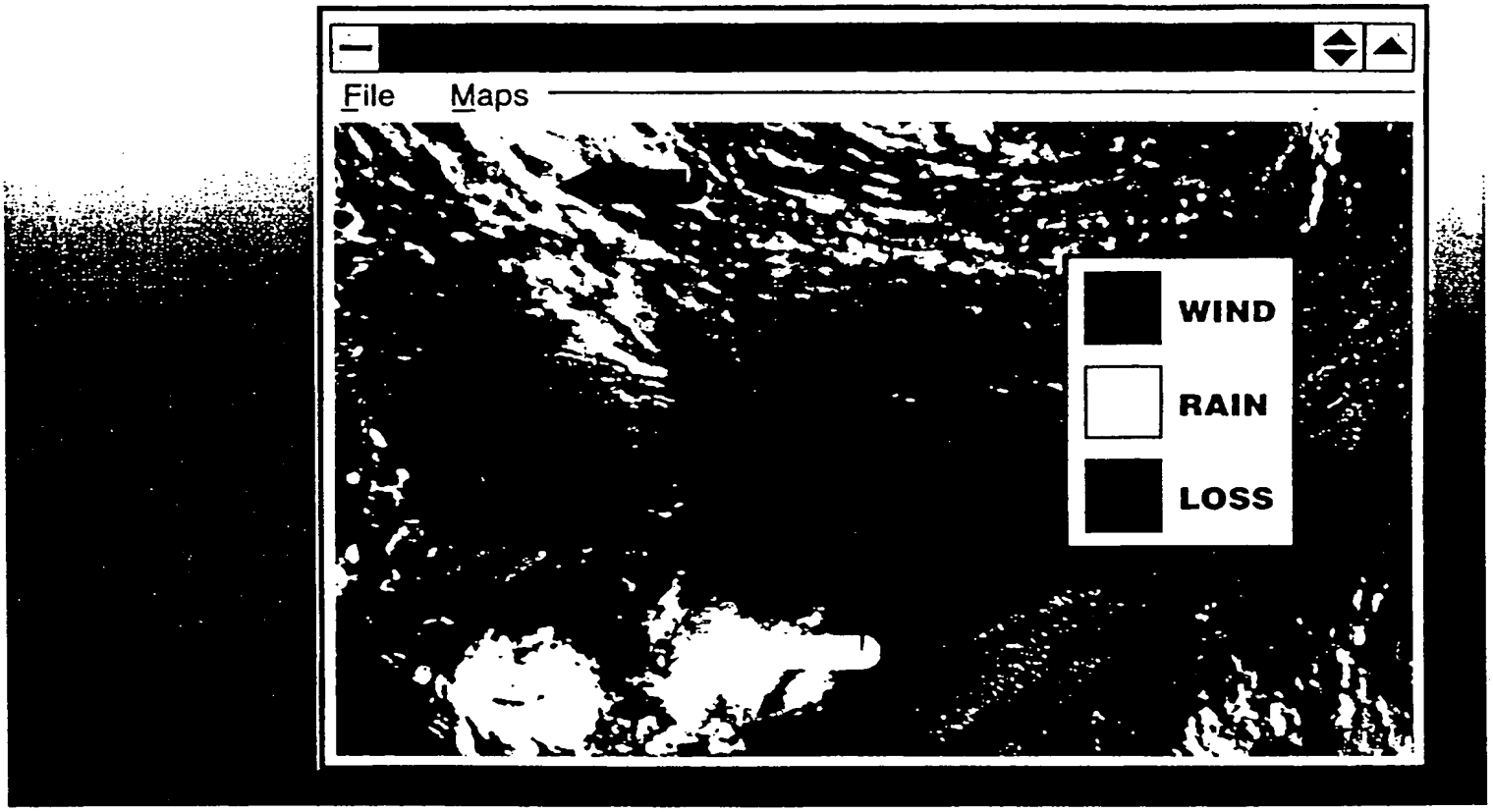
The companies report that business is brisk, especially since last year's massive hurricanes, Andrew and Iniki. Indeed, the companies' client lists feature the names of many top international reinsurance companies and intermediaries, including General Reinsurance Corp., American Re-Insurance Co., E.W. Blanch Co., Johnson & Higgins and several others. Interviews with executives from these and other insurance concerns indicate the software companies are providing a valuable service: helping to take the guesswork out of property reinsurance underwriting. "Reinsurers simply need to know in greater detail what the potential fallout can be from natural peril losses," says Hugo Johnsen, a director of Carpenter Bowring Ltd., the London-based brokerage. "Traditionally this has been somewhat of a guessing game. But with the huge losses of the past five years, reinsurers are desperately trying to get their hands around exactly what they are reinsuring and what they might have to pay out."

Catastrophe Analysis

Carpenter Bowring turned to EQE International, a risk and safety engineering consulting firm that licenses its software to companies and/or conducts computerized analyses in search of catastrophe exposures. For Carpenter Bowring, EQE conducted an all-risk analysis of earthquakes in Iceland. The government of Iceland insures all properties in the country and buys its reinsurance through Carpenter Bowring in the London market. "The government wanted to come to grips with the amount of damage that could happen in an earthquake," Mr. Johnsen says, "since they had undertaken to reimburse everybody in that event." Carpenter Bowring commissioned a

Russ Banham is a freelance writer based in Missoula, MT

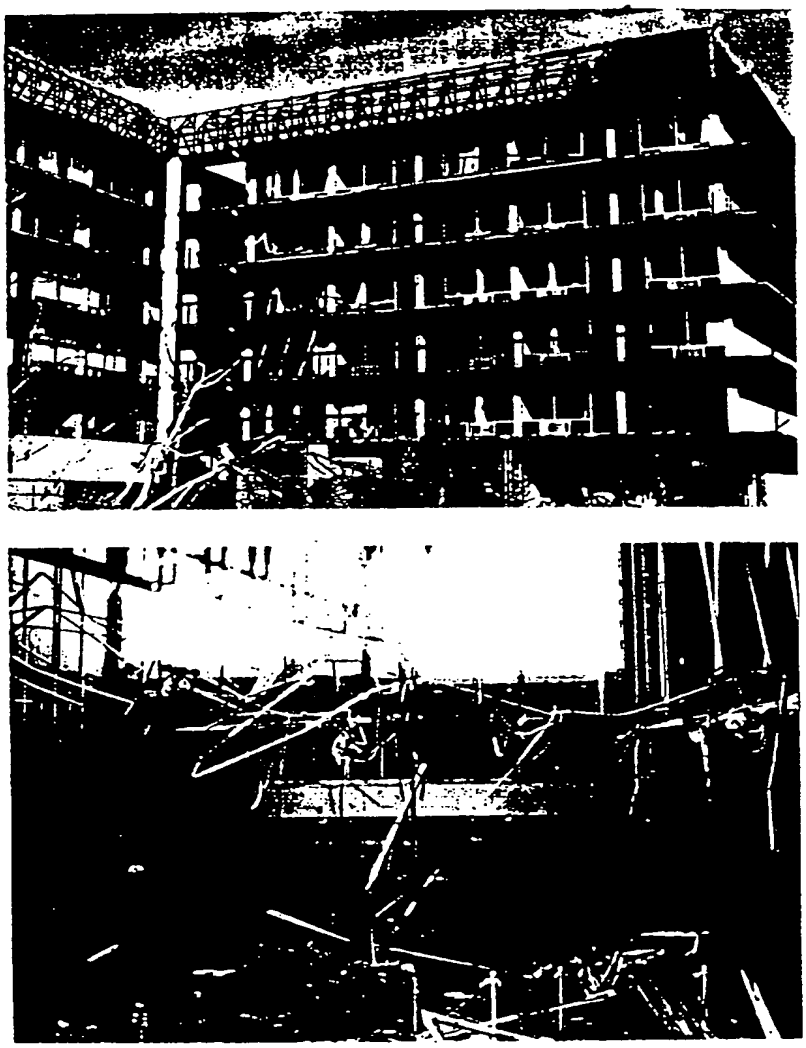
COMPUTER PREDICTIONS



study by EQE after its reinsurance company clients also requested it. EQE examined various types of construction in the country, then cross-referenced each with various "earthquakes" of different magnitudes. Its final report estimated insured property loss figures for each particular earthquake magnitude. Surprisingly, the study's findings raised concern over potentially huge property losses from a major earthquake. Carpenter Bowring's clients decided to raise their reinsurance premiums "by a double-digit increase," Mr. Johnsen says. The government was unable to afford the new premium and is now "going bare" without reinsurance, he adds.

Though primarily known for its work as a consulting firm specializing in structural and earthquake engineering, in recent years EQE has expanded its services to encompass risk assessment and management of other natural and even man-made hazards. "No one can predict Mother Nature," says Earl Aurelius, the company's vice president. "What we can do is develop a computer model that allows us to look at a reinsurer's portfolio relative to historic storms and how fierce they were," he says. "We can calculate the expected damage, providing the reinsurer with the ability to estimate potential damage given certain events. So, in essence, while we can't tell you exactly 'when,' we can tell you 'how much.'"

EQE's new windstorm hazard analysis software was unveiled in April at a conference sponsored by the London Insurance and



Devastation from Hurricane Andrew, which wreaked havoc on Florida in 1992

Reinsurance Market Association (LIRMA), an association of 130 international reinsurers based in London. EQE developed the software, called UKWIND, at LIRMA's request for use by its member companies. The software can instantly provide all the necessary information on windstorm hazard and related building damage in the United Kingdom on a single-risk-analysis basis. Users need specify only a postcode for the software to provide the maximum wind speeds for a selection of exposure periods at various probability levels.

For example, if one enters the postcode B1 2XF, for Birmingham, England, the computer will show that a maximum gust speed of 42.7 meters per second in a period of 50 years has a .50 level of probability in a given year. The software then inputs that information into a data base displaying selected types of building construction and evaluates the potential damage range. Using the same postcode, the computer indicates that a building made of light steel and weak cladding would suffer damage costing 5.1 percent of its replacement cost. In other words, if the building cost $1 million, the storm would result in a $51,000 loss.

The key to determining potential insured property damage losses is the underwriter's understanding of the structural integrity of a building, Mr. Aurelius says. EQE's engineers work with insurers to identify the critical factors in structural performance, i.e., to know what to look for in a particular building. The engineers even visit buildings after an earthquake or hurricane to see what happened and why to buildings of given heights and compositions.

EQE's work for LIRMA indicated that U.K. housing actually is less likely to be damaged from windstorm than housing in the United States. "The conclusion is reasonable, since housing in the U.K. tends to be masonry with relatively small openings and good wind-resistive roofing," Mr. Aurelius says. "Housing in the United States tends to be less wind-resistive wood frame, with more vulnerable larger openings and/or roof openings."

EQE's software licensing fee runs about $25,000 annually. Other insurers and reinsurers that have bought its software include Swiss Re, Eagle Star and Toa-Re, as well as a number of London insurance entities "who are unfortunately going out of business very rapidly," says Mr. Aurelius.

CATMAP and Catastrophes

The oldest catastrophe risk assessment package designed specifically for reinsurers was developed by Applied Insurance Research (AIR), and is called CATMAP. The package includes the software, which can be used on any personal computer, as well as a variety of support functions, including a disaster information hot line, user groups and newsletters. The program was designed in 1987 with the help of three reinsurance underwriters, says Karen M. Clark, AIR president.

Like EQE's UKWIND, CATMAP uses a property risk's five digit zip code in the United States (or British postcode) to evaluate the probable maximum losses from a windstorm, earthquake or other natural disaster. Once that data is entered, the computer generates the characteristics – location, size, intensity, direction, etc. – of a storm. Based on these characteristics, wind speeds are estimated for each zip code or postcode in the affected area, and insured damages are estimated and tabulated. "For example, we can tell a company that there is a possibility of a $250,000 loss one year in 20, or one year in 50, and so on," Ms. Clark says.

A reinsurer using CATMAP can calculate the cost of a variety of property-related risks,

Forecast For Weather Derivatives: Hot

P.D: 05/1998
P. 1/6 (6)

Winter, spring, summer or fall, all you have to do is buy a call.

By Robert Hunter

Modern scientists have sent men to the moon, produced Stealth bombers and cloned sheep. Yet, inexplicably, they still cannot produce a reliable weather forecast beyond one week. For energy producers and other corporates whose profits are affected by the weather, this is troubling. A milder-than-normal winter, after all, can have disastrous effects on companies ranging from power marketers to ski lodges to soup producers. Insurance companies have written catastrophic weather insurance policies for years, but what about corporates affected by noncatastrophic, seasonal weather conditions?

Last August, Houston-based energy giant Enron announced the first over-the-counter weather contract—a deal that allowed one counterparty, a Northeast utility, to protect its profits by creating payout situations when the temperature exceeded certain parameters. The weather derivatives market was off and running.

"We started looking into this business as a way to hedge our own weather exposure," says Lynda Clemmons, a director at Enron. "We went to a number of insurance companies and asked them for help in covering some of our weather risk. They said, 'If you want to protect, say, a $10 million exposure this summer, we'll charge you $6 million.' We figured there had to be a business in there somewhere, and we could probably offer the same sort of protection on a derivative basis."

Enron has done some 70 deals since the first one last August, and Kansas City, Mo.-based Aquila Trading and Risk Management and Houston-based Koch Supply and Trading have joined in the fun, transacting some 140 and 80 contracts, respectively, with counterparties from Alabama to Australia. Most of the deals involve contracts based on either heating or cooling degree days. A degree day is the deviation of a day's average temperature from 65°. In the summertime, the demand for energy increases with every degree day above 65, as customers crank up the air conditioning; in the wintertime, the demand increases for every degree day lower than 65 as customers rush for the thermostat.

Degree day contracts aren't the only products available. During the last six months Aquila has launched a suite of weather-derived products geared toward corporates of every ilk, including guaranteed rainfall, snowfall and snow depth, and guaranteed minimum, maximum and average temperatures. In January it announced its first sale of such a product, to Cigna Property & Casualty, an insurer looking for additional protection for one of its California-based clients hit hard by El Niño.

"We started looking into this business as a way to hedge our own weather exposure. We figured there had to be a business in there somewhere."

Lynda Clemmons
Director
Enron

While the biggest customers for weather derivatives thus far have been public utilities, agricultural and insurance industries, Aquila hopes to attract customers

from the entertainment, travel and leisure, construction, and real estate industries as well. "If you flip through a random stack of annual reports," says Ed Mills, senior vice president and general manager of Aquila Trading and Risk Management, "you'll find that the earnings of 80 percent or more are affected by the weather. In fact, the Internet could be the only industry not affected in some way." Aquila has sold around 100 non-degree-day weather contracts so far. Enron is exploring other weather derivatives as well, including rainfall and stream flow products, although it hasn't sold any to date.

A new paradigm

Gas and power are the most volatile commodities in North America. Within geographical regions, prices for power can vary widely as a result of transmission constraints, unit outages, differing reserve capacities and fuel transportation costs. Historically, energy producers have focused all of their attention on managing price risk. But the basic equation in the energy business is: the price of energy X the volume of energy demanded = a producer's revenue or a consumer's cost. How, then, are you supposed to handle the volume, or usage, side of the equation?

Traditional price risk management techniques are useless in hedging volumetric risk, because energy usage has a low correlation with energy prices. Aquila's Mills offers an example: "In the summertime, when temperatures spike upward considerably, one's first thought before turning on the air conditioner isn't 'What is the price of energy today?' The same holds true in the wintertime with heat." Colin Myer, senior vice president at Koch Supply and Trading, agrees. "Price and demand have little or no relationship in energy. The only driver of demand is weather."

The volatility of weather makes weather derivatives especially useful. Conditions can vary greatly within even narrowly circumscribed delivery regions, and extreme weather can necessitate expensive auxiliary unit startups, testing capacity constraints and causing extraordinary spot price spikes. "There's no such thing as overhedging," says Monte Simpson, a weather broker at Natsource. "Price hedging is essential, and so is volumetric hedging. The two go hand in hand."

Deregulation in the energy industry will allow the big power marketers to sell energy products virtually nationwide. "The more than 1,000 utilities and municipals in the United States right now will shrink to perhaps 100 in the next five years, and maybe less," says Shannon Burchett, president of St. Louis-based Ameren Energy, the trading arm of Ameren Corp. With such few companies enjoying such vast market reach, hedging weather exposures will be increasingly important. Many believe the energy industry will fuel tremendous growth in weather contract volume in the next few years. "The need to hedge heating and cooling degree days through derivative products will present itself to every electric utility," says Peter Fusaro, senior vice president at ABB Financial Services. "They're already hotter than a pistol, and the market's going to increase exponentially." Bob Greene, president of Aquila, thinks weather products will enjoy trading volumes greater than those of electric power.

Tricks of the Trade

While weather derivatives theoretically can be geared toward a number of industries, the energy business has had the pick of the litter to date. There are a number of weather strategies that can minimize weather risk. The simplest structure is the heating or cooling degree day swap, used to stabilize cash streams associated with cooling and heating energy or to guarantee production peak capacity. An energy producer that sells a swap will be compensated for a certain amount per degree day whenever degree days settle below or above an agreed strike level. When degree days settle above the strike, for example, the producer pays the buyer of the swap. The result: the combination of the swap and the producer's revenue from operations yields a more stable revenue stream, while the buyer sees a mirror effect.

Degree day options serve to provide a one-sided hedge on the downside while preserving the upside potential. The price for this, of course, is a fairly steep premium, but one that will decrease as the market becomes more liquid. In the most common degree day options, a producer buys a put and is paid a fixed amount per degree day whenever the degree days settle below an agreed strike—a typical floor option. This structure offsets potential revenue losses by establishing a minimum revenue floor. If degree days settle above the strike, the producer loses only the option premium, and can realize all of the remaining upside. Degree day collars act similarly, except that producers sell a call based on a high strike as well, creating a ceiling as well as a floor. The degree day possibilities are thus limited to the desired degree day range.

Certain "digital" structures can be used to facilitate lump-sum payments to parties when certain conditions are met. These are most useful when weather events bring about higher costs in fixed increments. For example, certain power producers are forced to operate expensive peak production facilities when particular temperature thresholds are reached, producing a two-tiered cost structure. The producer can buy a digital hedge to mirror this cost structure, thus stabilizing its cost stream.

Perhaps the most useful weather derivatives to energy firms are those that are embedded into physical-delivery contracts. Suppliers can structure delivery contracts such that if certain temperatures are reached—or other weather conditions occur—prices are adjusted accordingly. "We've done a lot of embedded weather agreements," says Koch Supply and Trading's Colin Myer. "They allow customers to account for weather conditions without negotiating a separate degree day contract. There's a lot of interest in that."

Degree day options have quickly become the vanilla contracts of the weather derivatives business. Aquila is hoping that its guaranteed weather suite products become the vanillas of tomorrow. Its guaranteed forecast product is based on the National Weather Service's four- to eight-day forecast. If, for example, the New York Yankees wanted protection against cold weather for their opening series, they could buy a put from Aquila in advance. If the average daily temperatures during the period fell below the forecast, the Yankees would be paid an agreed amount per degree for each below-average day. If the Yankees wanted to hedge for the entire season, they could buy a guaranteed precipitation option that pays, say, $50,000 each day that rainfall exceeds, say, half an inch above an agreed number of occurrences.

Suppose an electric utility in California is concerned that El Niño rains will damage its transmission poles and wires and thus cause major losses. It could buy a severe weather option from Aquila that pays, say, $50,000 per inch of total rainfall that exceeds, say, 18 inches for the season. Snowfall contracts work the same way. A municipality that wants to hedge against massive snow removal costs could purchase a severe winter weather option from Aquila that pays, say, $200,000 for each day that snowfall exceeds two inches above an agreed number of occurrences. Wind-generation plants that face problems when wind speed falls below certain levels often have to buy energy to make up for low-wind days. Guaranteed wind speed contracts can be used as price hedges to ensure that production costs are stabilized.

—R.H.

Irrational exuberance?

Not everyone agrees that weather derivatives will become an invaluable hedging tool for energy companies. "Weather derivatives are a snooze button for those who haven't quite awoken from the regulatory slumber," says the president of a risk management software firm. "They are popular because they are consistent with the structural modeling approach." Structural modeling, developed during the era of governmental regulation of the power industry, sought to determine pricing based on the interaction of the fundamental energy

price drivers. At the time, utilities used cost-plus-return models to negotiate rates with regulators. When the government determined that the numbers were wrong, it ordered rebates or surcharges to account for the difference.

The problem with using this approach in the future, says the software dealer, is that the marketplace is the only entity that can fully understand fundamental price drivers. The approach doesn't account for the true supply-demand dynamic—regulators had always intervened, muddying the waters. "Weather derivatives will prevent people from being weaned off of the cost-plus approach," he says. "People who don't understand price behavior are going to latch onto anything they can understand." And weather derivatives aren't even a complete hedge, he says. "Say you have a contract that's indexed to temperature. A hot day when all the power lines are up gives you a dramatically different price behavior from a day when one or more power lines are down. And what does a weather derivative do for you when a plant is closed down altogether?"

TEMPERATURE and Power volume: A case study

The following table indicates the distribution of heating degree days in New York City between 1948 and 1996. Each entry in the table represents a fraction of normal. For instance, .7 indicates that heating degree days are 70 percent of normal.

Time Period	Minimum	Q1	Q3	Maximum
November	.69	.91	1.08	1.37
December	.77	.91	1.09	1.38
January	.75	.86	1.11	1.31
February	.79	.93	1.07	1.28
March	.71	.90	1.09	1.24
November 1–March 31	.85	.95	1.06	1.17
December 1–March 31	.84	.91	1.05	1.14

As the table shows, weather causes volume for the period of November 31 to March 31 to fluctuate by more than 5 percent in half of the years, and as much as plus or minus 15 percent overall. November is the most volatile month, and February the least volatile. Power producers could minimize such effects by using heating degree day options such as puts, calls and collars.

—Source: Koch Supply and Trading

Such criticisms have hardly dampened the exuberance for the products thus far. In April, a weather derivatives conference sponsored by Netsource in New York was so swamped with curious attendees that some were turned away at the door. "I've never seen anything like it," says Koch Supply and Trading's Myer. "To say we're bullish is an understatement." By some accounts, the market has reached half a billion dollars thus far, and a proliferation of startup firms indicates that it will grow considerably in the coming years. Worldwide Weather Trading is the first firm whose sole business is weather derivatives. Underwritten by an insurance company, the firm makes markets in temperature and rainfall derivatives. Most of its deals thus far have been with Enron, Aquila and Koch, but it hopes to reach out to smaller end-users as the marketplace develops. "We're here to provide liquidity," says Andrew Freeman, vice president of the firm.

"If you flip through a random stack of annual reports, you'll find that the earnings of 90 percent or more are affected by the weather."

Ed Mills
senior vice president and general manager
Aquila Trading and Risk Management

Another firm to jump on the weather derivatives bandwagon is Pittsburgh-based WeatherWise. President Bernie Bilski notes that one of the first weather derivatives to hit the market was the "weatherproof bill," created in 1994. Weatherproof billing allows energy consumers to lock into guaranteed

energy bills for various lengths of time and thus manage their energy costs. WeatherWise, formed in 1996, eliminates weather risk for energy consumers. "Weather can be a bigger cause of uncertainty in energy bills than price, on a year-to-year basis," says Bilski. "We're looking at a number of weather derivatives, such as heating and cooling degree days, to lay off some of the risk we take on." The deregulation of the energy industry is expected to spark widespread use of weatherproof billing, as suppliers begin to compete aggressively for customers.

And weather derivatives desks are growing at the bigger dealers as well. Koch has five people working full time on weather derivatives, while Natsource has three full-time traders and two managers on a weather desk. "We're committed to it as a business," says president Jack Cogen. "In the past six to nine months, we've seen the market really start to take off."

Outlook

Although the forecast for weather derivatives seems quite sunny, a few clouds are expected linger for a while. "One problem with weather derivatives right now is that they're linear, meaning the payoff changes proportionately with the temperature," says Brian Scanlan, president of ZaiNet Software. "While the current products are useful, they don't address the positive correlation between price and the quantity of power consumed. That kind of derivative hasn't yet been offered, but when it is, we'll have something that's of real importance to the power and gas people."

> "We're committed to weather derivatives as a business. In the past six to nine months, we've seen the market really start to take off."
>
> Jack Cogen
> *president*
> *Natsource*

There are more immediate problems as well. "At this stage of the market," says Enron's Clemmons, "there are credit and reliability questions, and there are the growing pains that attend any new market. It's undisciplined at this point." The handful of market-makers in the business must take on huge amounts of risk to build liquidity. But the risks they are taking on aren't as massive as it appears at fist glance. The beauty of weather derivatives lies in their "diversifiability." Weather conditions are so volatile and so localized that companies can fairly easily lay off the risks they undertake. "Market-making is a function of self-hedging portfolios," says Gary Morsches, a vice president at Southern Co. "The vast geographic differences in weather make it possible to speculate even in a relatively illiquid market." In an increasingly correlated world, that diversifiability could make weather derivatives attractive to investors looking for products completely uncorrelated with, say, the Standard & Poor's 500.

According to Natsource's Cogen, there are five conditions necessary for a successful paper market: a large pool of market participants, a reliable index, little or no market manipulation, market volatility, and hedge or spread instruments. The weather derivatives market satisfies all five, he says. The group of participants is large, including utilities and local distribution companies, as well as insurance, energy trading, agricultural and construction companies. The indices used are provided by the National Weather Service (and, for stream flow contracts, the U.S. Army Corps of Engineers), and are thus as reliable as possible. And it is impossible to manipulate heating degree day data, although precipitation and snow pack levels are subject to some degree of human error. (Cogen advises that contracts specify precise measurement criteria.)

"Perhaps most important from a market standpoint," says Cogen, "participants need to be trading different things, because it's difficult to bring in natural buyers who want to buy on the uptick and natural sellers intent on selling on the downtick." There is a good potential base of direction traders in weather derivatives, he says, because spreads can be created between the insurance market, which tends to look toward long-term, many-standard-deviation risks, and the capital markets, which look toward short-term, one-standard-deviation

risks.

And the market is maturing rapidly. Enron, Koch and Aquila are working to standardize contracts to provide a template for others to follow. "There are great opportunities for market-makers already," says Energy Imperium's Joe Pokalsky. "Whether or not the weather derivatives business gets big depends on how much value the market-makers add to the market." Koch Supply's Myer is optimistic. "In the last week, three or four major players have told me they've made a decision to staff up." In the derivatives biz, the motto may well be "staff up or shut up."